Evaluation of dynamic models for refrigeration system components

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ABSTRACT

There is a paucity of proven models for predicting the energy transients of walls used in low temperature applications and pressure vessels commonly used in refrigeration plants. The aim of this work was to investigate how the accuracy of feasible models for these situations was affected by changing model complexity.

Wall models were developed by assuming each wall layer could be represented by one of five possible thermal behaviours: null, resistance only, capacity only, alternating resistance and capacity (lumped) or fully distributed resistance and capacity. A range of feasible models for each of four common low temperature wall types was investigated by comparison of simulated behaviour to predictions by a finite element model (which was itself validated by comparison to experimental data for wall systems). Several model evaluation measures are presented to aid engineering judgement in selecting appropriate wall models for particular applications.

Only resistance needs be considered for accurate prediction of mean heat flux entering a room. It is recommended that metal layers be represented by capacity only models, thin insulation layers by resistance only models, thicker insulation layers by lumped or fully distributed models, and concrete layers by lumped or fully distributed models. The recommended number of zones within a lumped or distributed model for a layer rises as the amplitude of the expected repeating temperature cycle for that layer increases.

Four models of different complexity were derived to represent a typical industrial intercooler (pressure vessel). These models were tested by comparison of predictions to the measured time-temperature response of two pilot plant calorimeters containing R134a, when subjected to changing heat inputs. The measured response rate was most strongly influenced by sensible heat storage in the calorimeter shells and liquid refrigerant. Little difference in predictions by the four models was obtained in spite of the less complex models neglecting many known physical phenomena. A model considering only the thermal capacity in the shell and liquid refrigerant predicted rates of temperature change within 10% of predictions by all other models, and also close to the experimental data. An industrial case study suggested that the conclusions from the calorimeter study may be valid over much wider ranges. Suggestions are made on ways to improve the simplest model accuracy, and to gain greater benefit from the more complex models.

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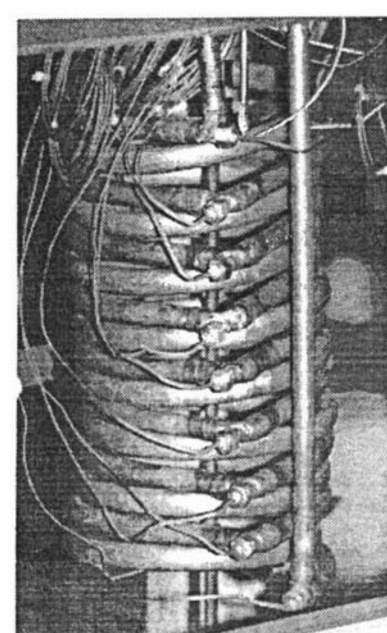

Coil of the Star calorimeter.
Picture by Paul Shepperd (1995)

"The important thing is not to stop questioning. Curiosity has its own reason for existing. One cannot help but to be in awe when he contemplates the mysteries of eternity, of life, of the marvellous structure of reality. It is enough if one tries merely to comprehend a little of this mystery every day. Never loose a holy curiosity".
-With apologies to Albert Einstein

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES